International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 4, No. 1, January 2015

Review Article

JOINING THE DIFFERENT MATERIALS USING FRICTION WELDING—A REVIEW

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Friction welding finds increasingly widespread in industrial applications as mass -production method for joining the parts and is widely used in various industries. To improve the production facilities, research has been done on various set of friction welds to analyze the fatigue strength, tensile strength and hardness test of various materials. Many variants in friction welding are studied to get better results and problem optimization. A survey about friction welding for joining the different materials is carried out as review report in this paper.

Keywords: Friction welding, Tensile strength, Fatigue strength, Aluminium, Steel

INTRODUCTION

Joining with friction welding of plastically deformed steel Sahin and Akata (2003) done the Friction welding process on plastically deformed steel. The investigation is based on the tensile strength, and it is done by changing the thickness of the material. The hardness variation is done by micro hardness test. If width of the part increases the tensile strength decreases and hardness of the material increases. Decrease in tensile strength is related to the hardness variation. Hardness can be increases by rapid cooling and the weld strength is not affected prior plastic deformation due to two reasons, they are due to plastic deformation in friction welding process is larger than the degree of prior plastic deformation and the effect of prior plastic deformation is removed in welding zone due to high temperature in the welding zone. As a result, plastically deformed steels can easily be applied by friction welding method.

Joining with friction welding of high-speed steel and medium-carbon steel Sahin (2005) done Friction welding on high speed steel and medium carbon steel. Tensile strength, Notch impact test and Fatigue test are done on the materials. Fatigue tests were conducted as superimposing some fluctuating tensile loads on a constant tensile load. Tensile stress amplitudes are 225 MPa.The welded parts are

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exposed to the notch impact tests, the joints are easily fractured. Therefore, some of welded parts and machined base parts after annealing at 650 °C for 4 h were exposed to the notch-impact tests with the charpy method. The notch-impact toughness of welded parts is slightly higher than that of high speed steel parts having the weakest notch-impact toughness. In the microstructure of welded parts, it is seen that the burr on medium-carbon steel side of the joints is bigger than that of high-speed steel.

The microstructure of medium-carbon steel after welding consists of ferrite and pearlite. The microphotograph of high-speed steel of the joint after welding consists of austenite and martensite that are called as polyhedral structure. Hardness variation was obtained by micro hardness testing in no-annealed joints were obtained higher than those in annealed joints at 650 °C for 4h. It is noted that the hardness increase takes place in the welding zone. Therefore, the welded parts become more brittle than the annealed parts. The tensile strength of the joints increases together with the friction time and pressure, and it raises a maximum, but it decreases for more friction time and pressure. The fatigue strength of the welded joints shows similar behaviour like the tensile properties. Thus, it can be concluded that welded parts are suitable for machine elements operated under dynamic loads. The hardness variations on medium-carbon steel side for annealed condition are lower than for the ones as-welded condition, which is a result of the reduced cooling rate during the post-weld annealing. The hardness drop close to the interface indicates decarburisation. The hardness is also reduced as a result of annealing on the high-speed steel, although it increases a little very close to the joint because of carburization.

LITERATURE REVIEW

Evaluation of the joint-interface properties of austenitic-stainless steels (AISI 304) joined by friction welding Sahin (2007) done Friction welding on austenitic-stainless steels (AISI 304). Tensile strength, Fatigue test and Notch impact test are done on the materials for experimental results. The effects of friction time and friction pressure on the strength of the joints were investigated in welding of parts. Welding experiments keeping the upset time and upset Pressure constant were directed to obtain proper friction time and friction pressure. Firstly, while friction pressure (60 MPa) was kept constant, friction times were changed. Secondly, while friction time (9 sec) was kept constant, friction pressures were changed. The tensile strengths of the joints increase as the friction time and friction pressure for the joints are increased more than optimum parameters, parts heat and deform much more. Therefore, the strength of joints decreases. The tensile stress amplitudes were changed between 150 MPa and 250 MPa. The fatigue strengths of welded parts are slightly lower than those of AISI 304 parts. In the notch impact test the fracture energy values were investigated. The notch-impact toughness of welded parts is nearly twice as those of AISI 304 parts. In the Microstructure of welded parts the burr that is produced in the equal steel joints is identical to both stainless steel sides. Hardness variations obtained by Vickers hardness testing and measuring locations on the horizontal direction and the vertical direction of welded parts. The hardness of the joints is decreased at interface zone of joint, these are due to the fact that the AISI 304 steel is not a hardened one by heat treatment. It is observed from the hardness variations and microstructures; AISI 304 austenitic-stainless steel has no considerable hardening effect in the welding zone of joints. The fatigue strength of the welded joints shows similar behavior like the tensile properties. Thus, it can be concluded that welded parts are suitable for machine elements operated under dynamic loads.

Characterization of mechanical properties in AISI 1040 parts welded by friction welding Sahin *et al.* (2007) had characterized the mechanical properties in AISI 1040 (high carbon steel) parts welded by friction welding. In Tensile Strength the effects of friction time and friction pressure on welding strength of the joints were examined in the welding of equal diameter parts. The changing of friction time and friction pressure results the changing of the welding strengths of the joints. The welding strength of joints reaches a maximum and, then goes down. Beyond the maximum point, the heat produced brings about meltings that decrease the welding strength. Fatigue tests were carried out with frequencies of 20 Hz. Welding interfaces are located in midsection of the fatigue specimen. Fatigue tests, such as superimposing some fluctuating tensile loads on a constant tensile load were conducted. The tensile stress amplitudes were changed between 180 MPa and 250 MPa. Fatigue strengths of welded parts are very close to those of 1040 steel, base metal. This coincides with the results of static tensile tests.

Dynamic responses of welded parts by friction welding were also examined with notch impact tests. The notched specimen was machined from welded parts according to the Charpy method with V shaped grooves. The notch-impact toughness values were obtained for both AISI 1040 and welded specimens and toughness of the welded parts is slightly bigger than that of AISI 1040 parts. Hardness variation was obtained by Vickers hardness testing and measuring locations on the horizontal direction and on the vertical direction of welded parts.

An experimental study on joining of severe plastic deformed aluminium materials with friction welding method Sahin *et al.* (2008) done a experimental study on plastic deformed aluminium materials using Friction welding. The experimental results are based on the Tensile strength, Micro structure examination, Hardness variation. The aluminium alloy specimens were prepared in cylindrical form by machining and were joined, and then the tensile strengths were investigated. The variation of calculated tensile strengths according to the friction time and friction pressure. The tensile strength of aluminium material increased because of severe plastic deformation. The microstructure-photos in the parent metals and welding zone of the joints after being etched in Keller's reagent. It is seen that the burr in joints is equal to the sides of both aluminium materials. Hardness variation was obtained by micro hardness testing and measuring locations on horizontal distance for welded aluminium material and welded plastic deformed aluminium. Severe plastic deformation increases both material strength and material hardness. The hardness of the joints decreases a little due to recrystallization-effect at the welding zone. The welding strength of the joints, which were obtained by welding of severe plastic deformed materials, was similar to the strength of the material after deformation. From microstructures and hardness variations of joints, severe deformed parts can suitably be welded with friction welding. And the strengths of the joints were obtained equal to material strength.

Characterization of properties in plastically deformed austenitic-stainless steels joined by friction welding Sahin (2009) had characterized the properties of plastically deformed austenitic stainless steel by friction welding. The experimental study is similar to the joint-interface properties of austenitic-stainless steels (AISI 304) based on tensile strength. The strength of joints was determined by tensile tests, and the results were compared with those of fully machined specimens. Tensile strength of the joints decreases as the diameter ratio increases in the plastically deformed parts. This result can be attributed to an increase in heat capacity due to heat loss by the rotation. Decrease in strength is related to the hardness variation within Heat Affected Zone (HAZ). The hardness variation was obtained by the Vickers micro-hardness test under a load of 1 kg. Hardness in the horizontal direction decreases slightly at the central zone compared to the base metals.

The microstructure is examined by optical microscope, and the macro and microstructure of the joints were analysed. For the different diameter joints, the microphotographs of both HAZ in the joints were having the equal diameter and the machined parts in the joints having the equal and different diameter. Microstructure of the welding metal has the austenitic grain structure. This zone contains recrystallized grains due to recrystallization upon heat dissipation during welding of the plastic deformed parts. However, welding strength of the joints was not affected prior to plastic deformation. Tensile strength decreases as the diameter ratio of the joints increases. Hardness variations in the horizontal direction of plastically deformed AISI 304 austenitic-stainless steels have no hardening effects. Friction welding improves the grains in the microstructure.

Joining of aluminium and copper materials with friction welding Sahin (2010) done the experiment of joining aluminium and copper materials using Friction welding. Experimental results are based on the tensile test, EDX analysis, Hardness variation and Micro structure of welded parts. The strength of joints was determined by tensile tests, and the results were compared with those of fully machined specimens. As the friction time and pressure for the joints is increased, tensile strength of the joints increases up to a peak strength then decrease with further increase in friction time and pressure. Peak strength corresponds to about 70% that of aluminium parts and 50% that of copper parts. the axial shortening on the aluminium side is more than that on copper side. Thus, the aluminium material has experienced weld flash at the interface. This is due to the fact that melting point of aluminium is lower than that of copper.

The copper substrate exhibits an irregular grain. The grains of aluminium are elongated along the rolling direction. Scanning Electron Microscopy (SEM) and energy dispersive X-ray (EDX) analysis were performed in order to investigate the phases that occur at the welding interface. Strength of the joints is related to hardness variation within the HAZ. Hardness variation was obtained under 200 g loads by micro hardness (Vickers) testing. Aluminium was already work hardened before friction welding. Aluminium recovered and recrystallised as a result of frictional heat and deformation, thus was slightly softened. Hardness variations on the copper side are more than those on the aluminium side. This variation is due to comparatively high thermal conductivity of copper. Hardness variations on the aluminium side were lower than those on the copper side as expected.

Friction welding of different materials Sahin (2010) had done Friction welding on different materials. The materials used in this experiment Stainless steel, Aluminium and Copper.

Friction Welded Aluminium and Copper Materials: Aluminium alloys are used more due to their superior workability and less expensive cost. For superior strength and good weldability in various structures, it is necessary to join stainless steel and aluminium materials.

Friction Welded Stainless Steel and Copper Materials: Welding is possible within the limited range of the welding conditions although problems for welding exist because of brittle intermetallic compounds and high thermal conductivity. To minimize the problems, the friction welding parameters must be taken into consideration for strong welds. The maximum strength obtained in the joints is about 75% that of copper parts having the weakest strength. It can be seen that around the interface, the hardness of the copper increases slightly.

Friction Welded Aluminium and Copper Materials: Aluminium and copper are continually replacing steels in electricity supply systems to reduce cost. However, welding of copper and aluminium are usually difficult by conventional fusion welding processes because those have the high thermal diffusivity higher than in many steels alloys. To overcome the problem the friction welding which is one of the solid state welding techniques is applied to the joining of copper and aluminium material. The hardness variations on the copper side are more than those on the aluminium side. This variation is possible due to comparatively high thermal conductivity of copper material.

Tensile strengths for joints were considered as positive result when compared with those of the base metals. But, some of the welds show poor strength depending on some accumulation of alloying elements at the interface result of temperature rise and the existence of a grey layer. The hardness variations are harmonious with previous works.

CONCLUSION

Hence, the behavior of various materials during the friction welding process has been studied. The author observed and summarized the following reports. (1) Friction welded steel has good tensile strength, good weldability. (2) Friction welded high carbon steel are more hardened than other materials, and (3) The microstructures of friction welded copper materials are good. An attempt has been made to analyze the properties of Copper and Zinc using friction welding process.

HISTORY OF SURVEY

Some literature survey about friction welding by M.Sahin has been made for a short period of seven years, i.e., 2003 to 2010. From that study the following observations are made.

REFERENCES

1. Sahin M and Akata H (2003), "Joining with Friction Welding of Plastically Deformed Steel", pp. 239-246, Trakya University, Edirne, Turkey.
2. Sahin M (2005), "Joining with Friction Welding of High-Speed Steel and Medium-Carbon Steel", pp. 202-210, Trakya University, Edirne, Turkey.
3. Sahin M (2007), "Evaluation of the Joint-Interface Properties of Austenitic-Stainless Steels (AISI 304) Joined by Friction Welding", pp. 2244-2250, Trakya University, Edirne, Turkey.
4. Sahin M, Akata H and Turgut Gulmez (2007), "Characterization of Mechanical Properties in AISI 1040 Parts Welded by Friction Welding", pp. 1033-1038, Trakya University, Edirne, Turkey.
5. Sahin M, Akata H and Kaan Ozel (2008), "An Experimental Study on Joining of Severe Plastic Deformed Aluminium Materials with Friction Welding Method", pp. 265-274, Trakya University, Edirne, Turkey.
6. Sahin M (2009), "Characterization of Properties in Plastically Deformed Austenitic-Stainless Steels Joined by Friction Welding", pp. 135-144, Trakya University, Edirne, Turkey.
7. Sahin M (2010), "Joining of Aluminium and Copper Materials with Friction Welding", pp. 527-534, Trakya University, Edirne, Turkey.
8. Sahin M (2010), *Friction Welding of Different Materials*, Trakya University, Edirne, Turkey.